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The Discovery and Observations of the Hard X-ray Transient Source GRS 1009-45 by the WATCH Instrument of the GRANAT Observatory

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Abstract – The history of the discovery and localization of the transient X-ray source GRS 1009-45, with the WATCH instrument of the GRANAT observatory in September 1993, is presented. At its peak, the source reached 0.8 of the Crab nebula brightness in the 8 - 60 keV energy band. This X-ray source distinguishes itself with the high spectral hardness that is comparable to the spectral hardness of the Crab nebula. In this paper we present light curves of GRS 1009-45 in two energy bands from September through October of 1993.

HISTORY OF DISCOVERY

A new X-ray source was discovered by the WATCH instrument [1, 2], which forms part of the scientific equipment of the GRANAT international astrophysical observatory. It was detected for the first time on September 11.6 UT, 1993 in the 20 - 60 keV energy band at a 180 mCrab level. It is remarkable that in a softer X-ray band, 8 - 20 keV, the source was not detected through September 12, when its light abruptly increased and reached a value of 0.7 - 0.8 of the light of the Crab nebula in both energy bands. The Crab nebula and a bright X-ray source Vela X-1 were simultaneously in the field of view of the WATCH detector. This enabled us to fairly accurately estimate the brightness of the newly discovered source. IAS Circular [3] was brought out following the discovery of the source.

LOCALIZATION

The high brightness of a newly discovered source and the presence of luminous sources Vela X-1 and the Crab nebula in the sight of the detector allowed its confident localization. We determined the following position of the source (equinox 1950.0):

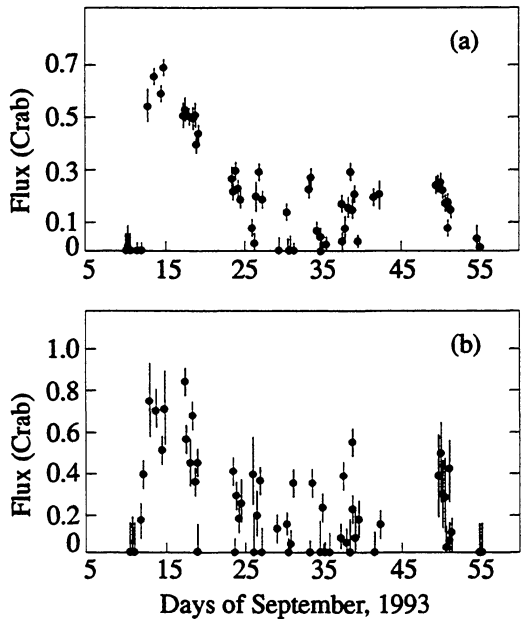
$$\alpha = 10^{h}09^{m};$$

$$\delta = -44°55'.$$

The uncertainty of the coordinates on the level of one standard deviation is a circle with a radius of 1°. The source was named GRS 1009-45. The measured coordinates agree well with the position measured with the GRO observatory that has confirmed the discovery [4].

LIGHT CURVES

From the first detection of GRS 1009-45, we were almost constantly watching for a change in its brightness. As we mentioned before, the increase in the source's light was first detected in the harder energy band, 20 - 60 keV. In the 8 - 20 keV band GRS 1009-45 was discovered nearly a day later (12.6 UT). This was during the subsequent set of observations. It is likely, that the source burst out in the soft band in the period 12.2 UT to 12.5 UT, when there was a break in com-



Light curve of GRS 1009-45 from September to October 1993, reconstructed from the data of the WATCH instrument: (a) in the 8 - 20 keV band; (b) in the 20 - 60 keV band.

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Table 1

Date (days of September, 1993)	Date error (days)	8 - 20 keV		20 - 60 keV		Date (days of September, 1993)	Date error (days)	8 - 20 keV		20 - 60 keV	
		flux (Crab)	flux error (Crab)	flux (Crab)	flux error (Crab)			flux (Crab)	flux error (Crab)	flux (Crab)	flux error (Crab)
10.503	0.107	0.000	0.055	0.000	0.158	30.953	0.108	0.000	0.045	0.039	0.051
10.719	0.107	0.023	0.055	0.000	0.175	31.290	0.228	0.000	0.020	0.347	0.082
10.934	0.107	0.000	0.056	0.000	0.161	33.557	0.098	0.232	0.036	0.000	0.052
11.618	0.188	0.000	0.021	0.162	0.090	33.755	0.099	0.276	0.034	0.345	0.075
12.021	0.215	0.000	0.018	0.391	0.078	34.568	0.109	0.080	0.032	0.000	0.159
12.847	0.096	0.548	0.062	0.763	0.179	34.786	0.107	0.055	0.033	0.223	0.065
13.672	0.213	0.662	0.033	0.720	0.106	35.132	0.239	0.001	0.031	0.000	0.042
14.498	0.101	0.592	0.036	0.520	0.072	35.588	0.216	0.026	0.025	0.000	0.071
14.774	0.174	0.693	0.043	0.725	0.158	37.608	0.107	0.181	0.031	0.074	0.067
17.516	0.099	0.515	0.036	0.859	0.074	37.824	0.108	0.039	0.031	0.383	0.066
17.711	0.095	0.533	0.037	0.570	0.067	38.125	0.193	0.088	0.047	0.043	0.060
18.011	0.205	0.512	0.027	0.454	0.115	38.566	0.107	0.172	0.034	0.000	0.163
18.495	0.098	0.506	0.036	0.691	0.072	38.792	0.118	0.302	0.031	0.549	0.067
18.689	0.095	0.515	0.037	0.353	0.073	39.018	0.107	0.167	0.034	0.212	0.067
18.880	0.095	0.403	0.037	0.452	0.080	39.305	0.179	0.219	0.040	0.076	0.123
19.072	0.096	0.447	0.036	0.000	0.161	39.686	0.202	0.039	0.026	0.163	0.080
23.565	0.106	0.277	0.035	0.404	0.074	41.692	0.150	0.208	0.033	0.000	0.092
23.776	0.104	0.227	0.035	0.004	0.064	42.540	0.081	0.218	0.058	0.140	0.090
23.986	0.105	0.302	0.035	0.285	0.079	49.739	0.072	0.252	0.040	0.347	0.185
24.276	0.184	0.232	0.033	0.168	0.074	49.883	0.072	0.262	0.040	0.429	0.185
24.617	0.155	0.193	0.035	0.255	0.112	50.093	0.137	0.269	0.039	0.294	0.189
26.097	0.095	0.089	0.040	0.388	0.180	50.553	0.095	0.240	0.041	0.287	0.140
26.289	0.095	0.030	0.040	0.000	0.177	50.754	0.105	0.194	0.034	0.024	0.171
26.558	0.141	0.208	0.045	0.188	0.109	50.950	0.090	0.194	0.032	0.380	0.147
26.891	0.191	0.296	0.029	0.358	0.084	51.131	0.091	0.093	0.032	0.051	0.147
27.277	0.194	0.198	0.028	0.000	0.086	51.390	0.168	0.160	0.023	0.103	0.119
29.554	0.095	0.000	0.038	0.122	0.082	54.883	0.091	0.049	0.043	0.000	0.150
30.523	0.106	0.148	0.032	0.144	0.052	55.066	0.091	0.016	0.032	0.000	0.150
30.737	0.107	0.000	0.031	0.000	0.068						

munications and there were no recorded observations with WATCH. The figure presents a light curve of GRS 1009-45 from September to October of 1993 in the two energy bands based on the WATCH data. This light curve is also catalogued in the table. In the figure, statistically significant variations of the source's intensity lasting several hours are visible. Note that similar fast variability was observed in the Musca X-ray Nova, also discovered by the WATCH instrument [5]. According to our data, the spectral hardness of GRS 1009-45 (defined as the ratio of flux in the 20 - 60 keV band to that in the 8 - 20 keV band) is equal to the spectral hardness of the Crab nebula. It remained essentially unchanged after the outburst.

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